

This paper records for the first time the occurrence of *Stylosanthes fruticosa* (Retz.) Alston from Rajasthan. It is known, so far, from the plains of Gujarat and Tamil Nadu (Matthew 1983). The specimens of *Stylosanthes fruticosa* collected from Alniyavas, Degana tehsil, Nagaur district have been housed in the Herbarium, Department of Botany, Government Dungar College, Bikaner, Rajasthan. The identification of the species is based on Matthew (1983).

*Stylosanthes fruticosa* (Retz.) Alston in Trimen, Fl. Ceylon 6 (suppl.): 77. 1931; Nooteb, Rainwardtia 5: 449. 1961; Verda, Kew Bull. 24: 59. 1970; Matthew, III. Fl. Tamil Nadu Carnatic t. 224. 1982.

*Stylosanthes mucronata* Willd., Sp. Ppl. 3: 166. 1802, nom. illegit.; Wight & Am. Prodr. fl. Ind. orient. 218. 1834; Hook f. Fl. Brit. India 2; 148. 1876; Gamble. Fl. Madras 1: 326 (230). 1918; Matthew, Mat. Fl. Tamil Nadu Carnatic 198. 1981.

Subshrub to 75 cm; branchlets appressed tomentose. Leaves trifoliate, to 1.5 cm; leaflets oblong-elliptic, 0.7-2.5 x 0.5-0.7 cm, chartaceous, prominently nerved, base subacute, margin ciliate, apex obtuse, stiff-mucronate; petiole to 8 mm; petiolule up to 1 mm; stipules 2 mm, adnate to petiole and sheathing. Flowers, 3-5 in terminal heads, sessile 4 mm across;

primary bracts to 1.5 cm, bristly; secondary bracts to 6 mm; bracteoles 2. Receptacle 6 mm long, filiform, tomentose; upper 4 calyx-lobes subconnate, to 1 mm, ciliate; lower one lanceolate, 2 mm. Corolla yellow; petals shortly clawed, inserted at the throat of calyx-tube; standard orbicular, 6 mm, claw 6 mm; wings obovate, 4 mm, auriculate; keels oblong, incurved, 4.5 mm, apex obtuse. Staminal sheath 4 mm. Stamens monadelphous; filaments unequal, 1-2 mm; anthers dimorphic. Ovary subsessile; ovules 2 or 3; style filiform, 1 cm, glabrous; stigma minute. Pod oblong, 4 mm, beaked; strongly nerved; seeds reniform, 2 mm.

**Flowers:** November-January.

**Pods:** December-February.

**Specimens Examined:** Forest area. Near Luni river, Alniyavas, Nagaur district Rajasthan. Sharma & Aggarwal. 1236 (Dungar College Herbarium)

**Distribution:** Africa, Madagascar, Sri Lanka, India.

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### 20. POLLINATION BIOLOGY OF THE ORCHID TREE *BAUHINIA VARIEGATA* L. (CAESALPINIACEAE) IN THE EASTERN GHATS, INDIA<sup>1</sup>

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The flowers of Caesalpiniaceae are less specialised than those of their counterpart members of Mimosaceae and Papilionaceae. They are open, usually with exposed pollen and nectar available to specialised and non-specialised pollen vectors (Hokche and Ramirez 1990). The species of Caesalpiniaceae exhibit a great variety of pollinating agents and mechanisms with an entomophilous trend (Arroyo 1981). The genus *Bauhinia* contains about 250 species distributed in the tropics of both hemispheres. It has 37 Indian species with flowers white, yellow and variegated red, and yellow. Vogel (1954) reported that *B. galpinii* and *B. mucronata* are sphingophilous in Africa, and Arroyo (1981) based on floral characteristics suggested that many other species of *Bauhinia*

are probably sphingophilous. Hokche and Ramirez (1990) reported that pollination biology in neotropics is associated with the life form of *Bauhinia* species. Tree species *B. aculeata*, *B. multinervia*, *B. pauletia* and *B. unguolata* have large white flowers and produce more nectar with high sugar concentration. In *B. aculeata*, the nectar is sucrose rich, and in other species it is hexose rich; but all these tree species are mainly nocturnal and bat-pollinated. Fischer (1992) also reported bat-pollination in *B. unguolata*. Liana species, *B. glabra*, *B. guianensis* and *B. rutilans*, produce relatively small diurnal flowers with different colours and variations in form and colour of the upper petal; all these are pollinated by bees, wasps, butterflies and hummingbirds (Hokche and Ramirez 1990).

In India, Ali (1933) reported that *B. racemosa* and *B. purpurea* are bird-pollinated. Subba Reddi and Bhaskara Rao (1993) reported subsequently bees, wasps and butterflies that pollinate *B. purpurea*. The pollination biology of the other *Bauhinia* species has not been studied. *B. variegata* is a species of tropical and subtropical climates with hot dry summers and mild winters. It originated in the Eastern Asia in India and the Chinese provinces (CAB International 2000). Another source documented is a native to the northern India, Vietnam and south-eastern China (www.floridata.com). Hybridization between *B. variegata* and *B. purpurea* produces a naturally unstable sterile cultivar of horticultural value known as *B. blakeana* (Carol *et al.* 2005). The leaves, fruits, pods and exudates of *B. variegata* are edible by humans, and are consumed as a vegetable, and made into pickles and chutneys (CAB International 2000).

The plants of *Bauhinia variegata* at the Lotugedda-Lambasingi forest areas of the Eastern Ghats in Visakhapatnam district, Andhra Pradesh state, India were used for study during 2003-2005. As a deciduous tree, *B. variegata* sheds leaves prior to the flowering period, which falls during March-April. It produces large, colourful flowers in few-flowered panicles. The flowers are large, showy, fragrant, bisexual and zygomorphic. The sepals are green and irregularly lobed. The petals are 5, light purplish white; one petal is odd and 4.5 cm long with bright purple vertical streaks on the inner side. It is partly enveloped by a pair of 4.5 cm long lateral petals whose margins are in turn enclosed by a pair of 3.5 cm long anterior petals. The stamens are five, of which two are 4.5 cm long, one 4.4 cm and other two 3.8 cm; they are curved at the tip facing the odd petal. The anthers are dithecous and versatile in fixation. The style is long in some flowers and small in some others. In long-styled flowers, the style extends 1 cm beyond the anthers, and in small-styled flowers the style lies 1 cm below or almost equal to the level of the anthers. The style is curved at the tip and ends with a small filiform stigma. The ovary is green, flat, and monocarpellary with a single locule consisting of 12 to 14 ovules which arise on marginal placenta (Table 1).

The flowers open during early morning hours before sunrise and anthers dehisce after anthesis by longitudinal slits. The style and stigma curve upward. Nectar secretion occurs during late mature bud stage and centered at the flower base. The method of Dafni (1992) was used to measure nectar volume and Hand Sugar Refractometer to record nectar sugar concentration. A flower produces 7-10 µl of nectar with 30-32% sugar concentration in Day-1 flowers and 40-45% in Day-2 flowers. The corolla with stamens falls off on the 3<sup>rd</sup> day. Three hundred fresh flowers were tagged and followed to record natural fruit set rate. The fruits produced from these

flowers were used to determine seed set rate. These flowers showed that natural pod set rate is 11% and seed set 82%. The pods mature within 3 weeks (Table 1). Each pod produces 2-11 seeds but 8-9 seeds form in most of the pods.

*Bauhinia variegata* shows the characteristics of melittophilous flowers as per Faegri and van der Pijl (1979). The most prominent characteristics are broad and distinct odd petal with nectar guide, lateral pairs of petals providing adequate platform for landing insects, and production of a small amount of nectar consisting of higher sugar concentration, fragrance and zygomorphic floral configuration. The study recorded bees (*Xylocopa latipes*, *X. pubescens*, *Ceratina simillima*, *Apis dorsata*, *A. cerana indica*, *A. florea* and *Trigona iridipennis*) and passerine birds (*Dicaeum erythrorhynchos*, *Nectarinia zeylonica*, *N. asiatica*, and *Zosterops palpebrosa*) as foragers of *B. variegata*. Fred (1976) stated that sucrose is the chief sugar in the flowers of most of the plant species. The flowers pollinated by long-tongued bees produce sucrose-rich or dominant nectar while those pollinated by short-tongued bees like *Xylocopa* species most often produce hexose-rich nectar. The long-tongued and short-tongued bees visit *B. variegata* flowers equally suggesting that the nectar of the latter may be a mixture of sucrose and hexose sugars, and enable bees to load nectar to a great extent. Barker and Lehner (1974a, b) also experimentally proved this with honeybees. The bees, *Xylocopa* species and *Apis dorsata* made frequent flights between individual plants to collect nectar; the later also for pollen, and so effect both self- and cross-pollination. All other bees stayed on the same plant for a long period to collect both pollen and nectar and in effect made infrequent flights between individual plants. Such a foraging behaviour results primarily in self-pollination. Although *B. variegata* is a potential pollen and nectar source for the bees, other co-occurring and simultaneously flowering plants, *Garuga pinnata* (Burseraceae), *Bauhinia racemosa* (Caesalpinaceae), *Acacia sinuata* (Mimosaceae), *Gmelina arborea* (Verbenaceae), *Alangium salviifolium* (Alangiaceae) and *Careya arborea* (Lecythidaceae) attract them to different levels. Their attraction depends on the number of individuals of each of these plant species, their flower density and standing forage crop. The plant species such as *Acacia sinuata*, *G. arborea*, *Alangium salviifolium* and *C. arborea* have been reported to be pollinated by these bees and birds, and the last species also by bats (Solomon Raju and Rao 2002, 2006; Solomon Raju *et al.* 2004; 2005). Therefore, melittophily does not ensure reproductive success in *B. variegata* in the presence of other species that flower and provide ample forage simultaneously to bees in the habitat. It is in this context, the foraging activity of passerine birds observed assumes importance to promote pollinate rate, especially cross pollination.

**Table 1:** Floral characteristics of *Bauhinia variegata*

Parameter	Observation
Inflorescence type	Panicle
Flower color	Purplish white
Flower shape	Caesalpiniaceous
Time of anthesis	Early morning hours
Time of anther dehiscence (n = 50 flowers)	Immediately after anthesis
Mode of anther dehiscence	Longitudinal slits
Nectar volume per flower (n = 15 flowers)	8.5 ± 1.25 $\mu$ l
Nectar sugar concentration (n = 20 flowers)	30-32% in Day-1 flowers; 40-45% in Day-2 flowers
Flower lifespan (n = 15 flowers)	3 days
Pollinators (n = 67 hours)	<b>Bees</b> <i>Xylocopa latipes</i> <i>X. pubescens</i> <i>Ceratina simillima</i> <i>Apis dorsata</i> <i>A. cerana indica</i> <i>A. florea</i> <i>Trigona iridipennis</i> <b>Passerine birds</b> <i>Dicaeum erythrorhynchos</i> <i>Nectarinia zeylonica</i> <i>N. asiatica</i> <i>Zosterops palpebrosa</i>
Natural pod set (n = 500 flowers)	11 %
Natural seed set (n = 500 flowers)	82%
Pod maturation time (n = 20 pods)	Three weeks

Bird flowers are usually red and the birds use them as an excellent signal of a high calorific reward, but they do not have intrinsic preference for red flowers (Raven 1972). In the genus *Bauhinia*, insects and hummingbirds pollinate *B. glabra*, *B. guianensis* and *B. rutilans* which produce variously coloured upper petal (Hokche and Ramirez 1990). In the present study also, bees and passerine birds pollinated *B. variegata*. The odd upper petal seems to be the main attractant for birds to pay visits to flowers. The birds prefer concentrated sugar solution to dilute solution but bird flowers characteristically produce less concentrated nectar to discourage unwanted flowers (Bolten and Feinsinger 1978). *B. variegata* flowers produce nectar with high sugar

concentration and the nectar is expected to be a mixture of sucrose and hexose sugars in almost equal proportions; this characteristic is important for birds to visit them. The birds observed probe the flowers from the front to collect nectar and effect pollination. As birds are far flying, they promote cross-pollination in their search for nectar on different trees located in an area and in different areas to quench their thirst. The bird species mentioned above, utilized *B. variegata* as nectar source consistently until exhausted. They foraged throughout the day with more activity during forenoon. They landed on the flowering branch and approached the flowers slowly to insert their bill into the flower base for sucking nectar. In doing so, the bill, forehead and throat of the birds contacted the stigma first and later the anthers in long-styled flowers and both sex organs contacted almost simultaneously in small-styled flowers. As the nectar produced per flower is small in quantity, the birds visited different individuals in quest of more nectar effecting both self- and cross-pollination. Ali (1933) reported that *Nectarinia asiatica* and *N. zeylonica* pollinate purplish white flowers of *B. purpurea* and whitish-yellow flowers of *B. racemosa* in the Western Ghats of India. Subba Reddi and Bhaskara Rao (1993) later reported that different insects pollinate *B. purpurea*. The present study indicates that *B. variegata* with melittophilous pollination syndrome is pollinated by bees and passerine birds. Therefore, ornithophily gains importance in *B. variegata* in the context of simultaneously flowering plant species that attract bee species to different levels of flower constancy. With both melittophily and ornithophily, *B. variegata* is able to set fruit to 11% and this low fruit set seems to be compensated by a high seed set rate. The information provided on the association between *B. variegata* and bees and passerine birds is expected to be useful for their conservation in the habitat.

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## 21. *CERASTIUM FONTANUM* BAUMG. (CARYOPHYLLACEAE) – A NEW RECORD FOR RAJASTHAN<sup>1</sup>

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During a plant collection visit to Chattargarh, Bikaner district, Rajasthan, we collected *Cerastium fontanum* Baumg from marshy fields. A perusal of the literature shows that this genus has not been reported from Rajasthan.

The specimens of *Cerastium fontanum* Baumg are housed in the Herbarium, Department of Botany, Govt. Dungar College, Bikaner, Rajasthan.

The identification of the species is based on the FLORA OF INDIA (Sharma, B.D. and N.P. Bala Krishnan (1993), Vol. 2, B.S.I. Calcutta)

*Cerastium fontanum* Baumg Soc. Zool. Bot. Fenn. "Vanamo" 18:63. 1963. Flora of India 523, Vol 2 (1993).

Herbs, laxly caespitose, hirsute throughout or glandular-pubescent upwards. Leaves sessile, oblong, elliptic to ovate, acute at apex, 1-3 x 0.3-1.0 cm, minutely hairy. Cymes glandular-pubescent; bracts herbaceous. Sepals ovate-lanceolate, 3-5 mm long, with scarious margins and glabrous apex. Petals 2-fid for 1/3 to 1/5 of length, equalling or slightly exceeding sepals. Stamens 10; filaments glabrous; anthers yellow. Capsules narrowly cylindrical, 9-12 mm long; seeds 0.5-0.9 mm, reddish brown, rugose-tuberculate.

**Fl. & Fr.:** April-September.

**Specimens Examined:** Gowsala Chattargarh near Khala. Sharma & Kantiya. 1332

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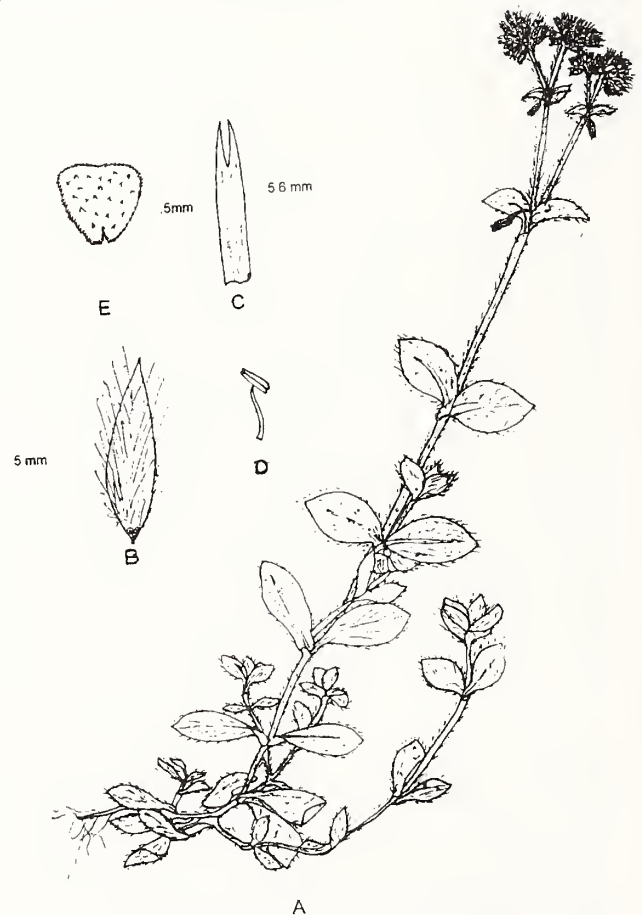


Fig. 1: *Cerastium fontanum* Baumg.  
A. Plant; B. Sepal; C. Petal; D. Stamen; E. Seed